



BSI Standards Publication

Space engineering — Adhesive bonding for spacecraft and launcher applications

National foreword

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A list of organizations represented on this committee can be obtained on request to its committee manager.

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Space engineering - Adhesive bonding for spacecraft and launcher applications

Assurance produit des projets spatiaux - Utilisations
du collage pour les structure satellites et lanceurs

Raumfahrtproduktsicherung - Adhäsionskleben für
Raumfahrt- und Trägeranwendungen

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European Foreword

This document (EN 16602-70-16:2021) has been prepared by Technical Committee CEN-CENELEC/TC 5 “Space”, the secretariat of which is held by DIN.

This standard (EN 16602-70-16:2021) originates from ECSS-Q-ST-70-16C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2022, and conflicting national standards shall be withdrawn at the latest by April 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Adhesive materials have a wide range of uses within the space domain however they are often qualified as a minor or negligible part of a large subsystem or system. This frequently results in unforeseen effects arising directly from the adhesive selection which impacts either the functionality, integrity or AIT activities. As a consequence whilst the adhesive is often the lowest cost element of the system it frequently has a high cost associated with the necessary recovery and delta qualification activities need to ensure the system level functionality. Both the system level qualification and any recovery actions are further complicated by the intrinsic relationship between the adhesive performance, the adherend and all the processes associated with the manufacture of the adhesive bond.

European space agencies and the space industry at present have a general handbook available for adhesive bonding (ECSS-E-HB-32-21) however there is no fixed scheme detailing the minimum requirements for verification of adhesive bonding process nor validation of an adhesive material.

Standardisation of the verification processes for adhesives and adhesive bonding across the European space industry is allowing a harmonised and consistent approach.

The generic approach facilitates the correct selection of data thus allowing streamlining of the industrial development activities and enabling the validation of adhesives and verification of adhesive bonding process at an early stage of a programmes lifetime.

This standard is further justified because of the high level of non-conformances (NCR) identified across industry due to limited early programmatic qualification programmes related to adhesive bonding and characterisation of adhesive materials.

1

Scope

The scope of the document addresses the generic verification for all types of adhesive bonding for space applications including evaluation phases. This standard covers all aspects of the adhesive bonding lifetime such as assembly, integration and testing, on-ground acceptance testing, storage, transport, pre-launch, launch and in-flight environments.

This standard does not cover requirements for:

- Adhesive bonding used in EEE mounting on printed circuit boards (for this subject see ECSS-Q-ST-70-61)
- Adhesive bonding used in hybrid manufacturing (for this subject see ESCC 2566000)
- Adhesive bonding for cover-glass on solar cell assemblies (for this subject see ECSS-E-ST-20-08)
- Design of adhesive joints (for this subject see ECSS-E-ST-32)
- Long term storage and long term storage sample testing
- Performance of adhesive bonds
- Functional properties of adhesive joints
- Co-curing processes
- Life-time aging prediction, neither on ground (humidity) nor in-orbit (thermal cycling)

This standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system – Glossary of terms
EN 16603-32	ECSS-E-ST-32	Space engineering – Structural general requirements
EN 16602-10	ECSS-Q-ST-10	Space product assurance -Product assurance management
EN 16602-10-09	ECSS-Q-ST-10-09	Space product assurance -Nonconformance control system
EN 16602-20	ECSS-Q-ST-20	Space product assurance -Quality assurance
EN 16602-40	ECSS-Q-ST-40	Space product assurance - Safety
EN 16602-70	ECSS-Q-ST-70	Space product assurance – Materials, mechanical parts and processes
EN 16602-70-02	ECSS-Q-ST-70-02	Space product assurance - Thermal vacuum outgassing test for the screening of space materials
EN 16602-70-09	ECSS-Q-ST-70-09	Space product assurance - Measurements of thermo-optical properties of thermal control materials
EN 16602-70-22	ECSS-Q-ST-70-22	Space product assurance - Control of limited shelf-life materials
EN 16602-70-71	ECSS-Q-ST-70-71	Space product assurance - Materials, processes and their data selection
	ISO 472:2013/ Amd 1:2018	Plastics - Vocabulary - Amendment 1: Additional items
	ISO 3696:1987	Water for analytical laboratory use - Specification and test methods
	ISO 15785:2002	Technical drawings — Symbolic presentation and indication of adhesive, fold and pressed joints

Terms, definitions and abbreviated terms

3.1 Terms from other standards

- a. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.
- b. For the purpose of this Standard, the terms and definitions from ECSS-Q-ST-70 apply, in particular for the following terms:
 - 1. critical process
 - 2. critical material
 - 3. special process
 - 4. request for approval
- c. For the purpose of this Standard, the terms and definitions from ECSS-Q-ST-40 apply, in particular for the following term:
 - 1. criticality

3.2 Terms specific to the present standard

3.2.1 adherend

body that is, or is intended to be, held to another body
[ISO 472:2013/Amd 1:2018]

3.2.2 adhesion

state in which two surfaces are held together by interfacial forces which can consist of chemical or mechanical or physical interfacial forces

3.2.3 adhesive bond

see “adhesive joint”

NOTE The term “adhesive joint” is commonly used, but for the process the term “bonding”.

3.2.4 adhesive bonding procedure

detailed instructions, equipment and tools needed to perform the adhesive bonding

NOTE Refer to Annex A for the detailed content.

3.2.5 adhesive bonding process

material joining process where an adhesive material is added in order to maintain chemical, mechanical or physical interfacial forces between bonded parts

NOTE The joining mechanism between adhesive and bonded parts, also called “adherend”, is adhesion-based. According to ECSS-Q-ST-70, adhesive bonding belongs to category of “special processes”.

3.2.6 adhesive joint

joint of two or more parts of similar or different materials made using adhesives
[ISO 15785:2002]

NOTE The term “adhesive bond” is synonymous

3.2.7 adhesive material

substance with the capability of holding two surfaces together by either chemical, physical or mechanical interfacial forces or a combination of them

NOTE The concept of adhesive materials is addressed in ECSS-E-HB-32-21.

3.2.8 ambient exposure in a controlled environment

item is exposed to ambient air with temperature in the range of $(22 \pm 3) ^\circ\text{C}$, and relative humidity $(55 \pm 10) \%$

NOTE 1 Long term exposure to these conditions can cause degradation of the adhesive joint's performance.

NOTE 2 Contributes to “intrinsic ageing” of the joints.

3.2.9 co-curing

earliest stage of the manufacturing process, resulting in a fully integrated component

NOTE 1 The joining mechanism is chemical cross-linking. Both adherends are undergoing chemical reaction.

NOTE 2 This standard does not cover requirements for the verification of co-curing processes.

3.2.10 co-bonding

intermediate stage of a manufacturing process when an uncured part is joined with one or more cured parts, typically with an additional layer of uncured adhesive

NOTE 1 The joining mechanism between the adhesive and the cured part is adhesion. Between the uncured part and uncured adhesive layer chemical cross-linking is taking place.

NOTE 2 Further text refers only to adhesive bonding or co-bonding (uncured adhesive, cured adherend) or to bonding with pressure sensitive tapes (PSAs).

3.2.11 degradation

undesired change of property of interest in a given time interval

3.2.12 hot-wet exposure

exposure where the test item is subjected to synergistic effect of gaseous water phase and temperature

NOTE 1 The test item is exposed to conditions where temperature and water vapour pressure, typically >25 °C and >65 % RH), are higher than in a controlled environment

NOTE 2 Performed in frame of simulation of on-ground environment within adhesive bonding verification test sequence or as part of independent hot-wet testing

NOTE 3 Inspection and verification of the test item before and after hot-wet exposure is non-destructive and does not prevent test item to be submitted for further testing in frame of verification test sequence

NOTE 3 Also known as “humidity exposure”

3.2.13 hot-wet testing

test where the test item is subjected to hot-wet exposure and the effect of hot-wet exposure is verified after hot-wet exposure is performed

NOTE 1 Hot-wet exposure can be performed in combination with other additional stresses, e.g. mechanical, chemical or electrical

NOTE 2 Functional properties of test item can be verified during hot-wet exposure “in-situ” conditions

NOTE 3 In hot-wet testing of the adhesively bonded joints, hot-wet exposure is typically followed by mechanical tests to verify degradation of the joint and reduction factor associated with hot-wet exposure

NOTE 4 Also known as “damp-heat” testing or “humidity testing”

3.2.14 knock-down factor (KDF)

overall factor that is applied to the material property to account for variations in material composition, service environment and structural geometry

NOTE It can consist of several reduction factors.

3.2.15 reduction factor

ratio between mean value of given material property of exposed test item set and of reference (unexposed) test item sets

NOTE Can be expressed as fraction or as percentage of initial reference value (remaining percentage of the property of interest).

3.2.16 representativeness level of test item

definition of how well or accurately the test item reproduces the similarity to flight model configuration

3.2.17 structural bond

bond which is capable of sustaining in a structure a specified strength level under a combination of stresses for a specified period of time

NOTE 1 to entry: The combination of stresses can, for example, include peel and shear forces, fluctuating loads, environmental exposure and steady load. An adhesive that is capable of forming a structural bond is commonly referred to as a "structural adhesive".

NOTE 2 The term "structural joint" is synonymous

[ISO 472:2013]

3.2.18 test item

manufactured assembly undergoing verification test sequence

NOTE The test item can be standard test sample, component or part fully representative to the flight hardware.

3.2.19 test item population

group of test items sets manufactured to complete specific test sequence, including all reference test items, on-ground simulation test items, mission simulation test items and launch simulation test items and spare test items

NOTE Group of items with same manufacturing history.

3.2.20 test item set

test items that follow an identical test sequence

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms and symbols from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
AIT	assembly, integration and test
CME	coefficient of moisture expansion
CTE	coefficient of thermal expansion
DMA	dynamic mechanical analysis

Abbreviation	Meaning
AIT	assembly, integration and test
DPL	declared process list
DRD	document requirements definition
DSC	differential scanning calorimetry
MLI	multi-layer insulation
MMPP	materials, mechanical parts and processes
NDI	non-destructive inspection
PA	product assurance
PPE	personal protective equipment
PSA	pressure sensitive adhesive
RFA	request for approval
RH	relative humidity
SDS	safety data sheet
T _g	glass transition temperature
TDS	technical data sheet
TGA	thermo-gravimetric analysis
TMA	thermo-mechanical analysis
TVC	thermal vacuum cycling
UV	ultraviolet

3.4 Nomenclature

The following nomenclature applies throughout this document:

- a. The word “shall” is used in this Standard to express requirements. All the requirements are expressed with the word “shall”.
- b. The word “should” is used in this Standard to express recommendations. All the recommendations are expressed with the word “should”.

NOTE It is expected that, during tailoring, recommendations in this document are either converted into requirements or tailored out.

- c. The words “may” and “need not” are used in this Standard to express positive and negative permissions, respectively. All the positive permissions are expressed with the word “may”. All the negative permissions are expressed with the words “need not”.
- d. The word “can” is used in this Standard to express capabilities or possibilities, and therefore, if not accompanied by one of the previous words, it implies descriptive text.

NOTE In ECSS “may” and “can” have completely different meanings: “may” is normative (permission), and “can” is descriptive.

- e. The present and past tenses are used in this Standard to express statements of fact, and therefore they imply descriptive text.

Principles of adhesive bonding

4.1 Overview

Adhesive bonding for space hardware varies from bonding of for example cable ties, to the complex structural bonding of load bearing parts. Some adhesive bonds can be inside the spacecraft, while others are exposed to space conditions including sometimes large temperature variations and radiation. Therefore the lifetime of each adhesive bond is carefully assessed before starting the bonding process. An overview of the different factors affecting the adhesive bonding performance is given in Figure 4-1.

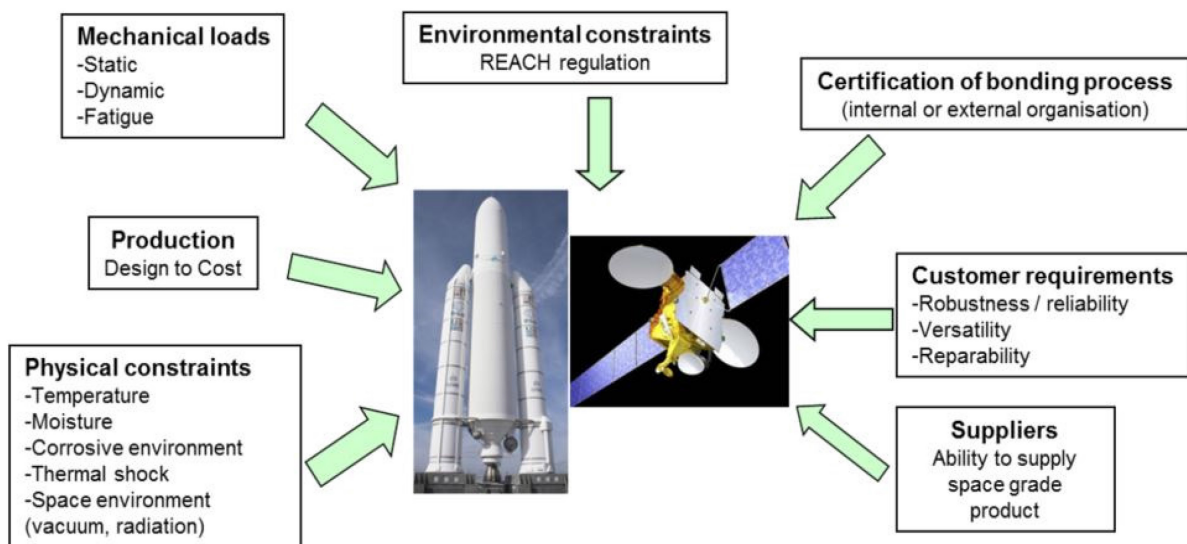


Figure 4-1: Overview of the constraints linked to adhesive bonds for space applications (not exhaustive)

4.2 Design of hardware

The design of bonded hardware involves parameters such as load direction and magnitude, CTEs, bonding gaps, accessibility. A detailed overview on how to design an adhesive joint can be found in sections 8 to 11 of ECSS-E-HB-32-21.

Designers or sizing engineers have a good understanding of how stresses are distributed across the joint when loads (mechanical and thermal) are applied to it. Typically they consider the general guideline for adhesive bonds to:

- Maximize shear and minimize peeling and cleavage load
- Maximize compression and minimize tensile loads
- Optimize the bond length to width ratio for shear loading

NOTE Increase the bond width is more efficient than to increase the bond length.

- In case of using fibre composite adherends the fibre orientation of the first ply is taken into account to optimize the joint performance.

4.3 Performance of the adhesive bond

After having defined the basic design of the hardware and the parts that are bonded, the analysis of the adhesive bond is performed. This analysis can focus on joint design, adhesive material properties and environmental constraints, see Figure 4-2.

The needed performance of the adhesive bond has an influence on the choice of the adhesive itself, regarding for example strength, curing process, surface treatment of the adherend and temperature stability.

More information on surface treatments of the adherends can be found in section 12 of ECSS-E-HB-32-21 and in ISO 17212:2012.

In case the needed performance cannot be achieved with the adhesives and surface preparations available, the design is changed to generate a more bonding-friendly setup (see Figure 4-2) or changed to another (for example mechanical) joining method.

4.4 Adhesive bonding process

The adhesive bonding process is considered as a “special process” in accordance with ECSS Q-ST-70 and generally taken into account in the early stages of the project.

The amount of time and personnel needed to perform the bonding depends on parameters like, the overall surface area, type of surface preparation, treatment, possible primer application, pot life and curing of the adhesive.

The bonding process steps can be described in individual procedures. For example the adhesive bonding procedure can refer to sub- procedures.

Examples of adhesive bonding process steps:

- Preparation of bonded parts (degreasing, cleaning, ultrasonic bath with organic solvents, drying condition)
- Surface treatment (by mechanical, chemical and physical means)
- Surface post-treatment (incl. final surface cleaning, surface protection and conditions of storage if not bonded immediately)
- Surface activation (by mechanical, chemical and physical means)

NOTE Adherends such as polymers can need a dedicated surface treatment to increase their surface energy.

- Surface quality verification (for example surface energy, roughness, wettability)
- Positioning and alignment of adherends
- Adherend priming (if any)

- h. Adhesive preparation (including conditioning and mixing)
- i. Adhesive application
- j. Adhesive curing in bonded assembly
- k. Bonded assembly verification (NDI inspection after cure – visual, dimensional check, mechanical load proof test)

NOTE 1 The same process steps are applicable for in-process samples.

NOTE 2 This list with examples is not exhaustive and steps are not mentioned in a strict chronological order.

In the case of adherends that are sensitive to ageing in storage conditions (UV, humidity, temperature over time) a specific surface preparation process can be applied to remove the affected surface layer.

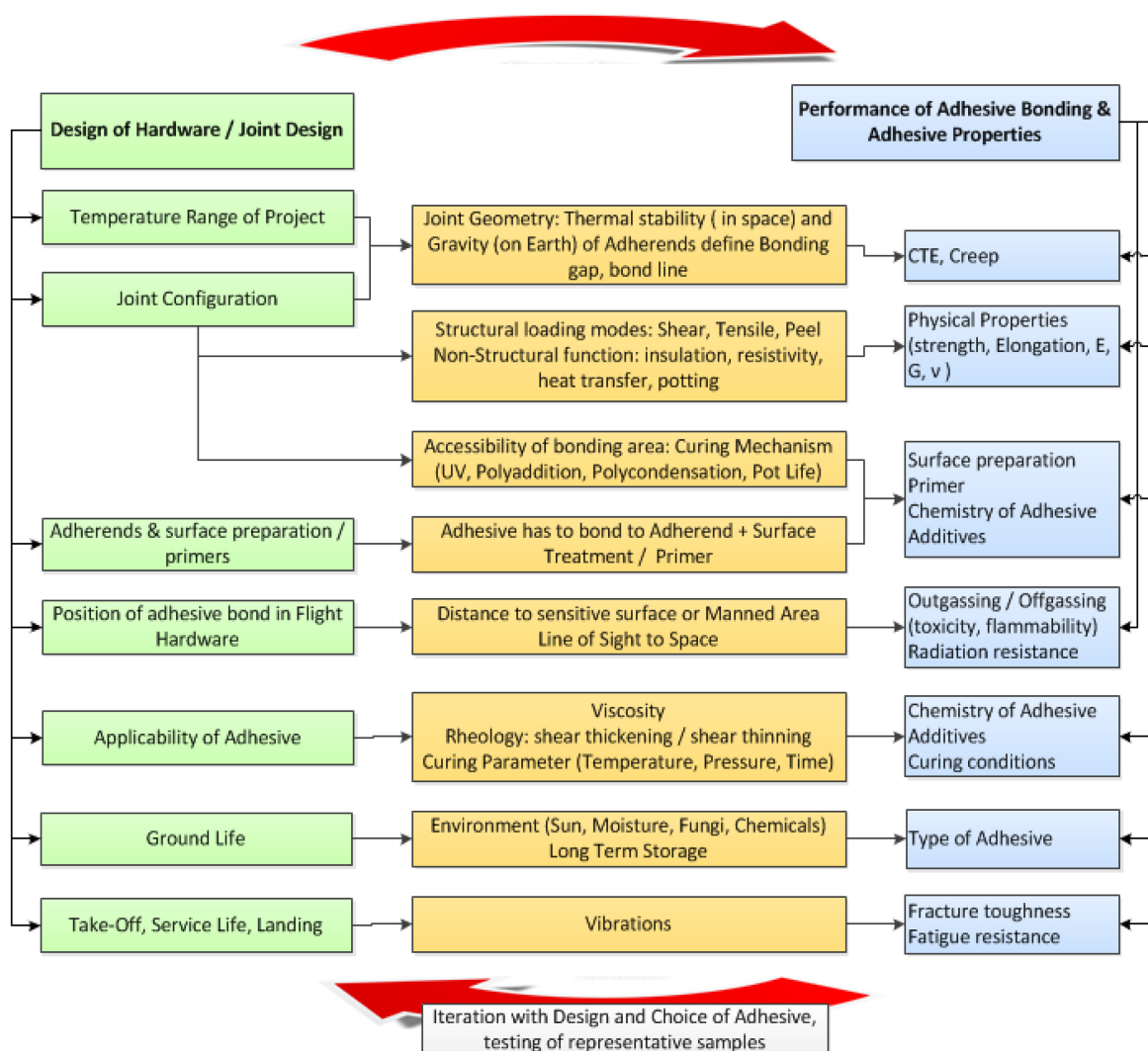


Figure 4-2: Overview on some parameters influencing the adhesive bond and its design

For a more detailed design chart see Figure 10.16-1 in ECSS-E-HB-32-21.

Selection of adhesive

5.1 Overview

The selection of an appropriate adhesive depends on a wide range of factors from early stage of manufacturing over service life till the end of mission. The ECSS Adhesive Bonding Handbook ECSS-E-HB-32-21 gives information about adhesive characteristics and properties and adhesive selection.

5.2 Analysis of adhesive application

- a. Selection of materials for adhesives shall be in compliance with requirements from clause 5 of ECSS-Q-ST-70.

NOTE Requirements from clause 5 of ECSS-Q-ST-70 include: for example: vacuum, radiation, moisture.

- b. Selection of adhesives shall be in compliance with clause 4.2.11 of ECSS-Q-ST-70-71.
- c. Depending on the cured adhesive properties, selection of adhesives shall be in compliance with requirements from clauses 4.2.17, 4.2.18 and 4.2.19 of ECSS-Q-ST-70-71.

NOTE Adhesive materials can be also grouped to elastomers (clause 4.2.17), thermoplastic (4.2.18) and thermosets (4.2.19).

- d. Selection of adhesive tapes shall be in compliance with clause 4.2.12 of ECSS-Q-ST-70-71.
- e. The outgassing characteristics of selected adhesive material in cured state shall be in compliance with requirements from clause 5 of ECSS-Q-ST-70-02.

NOTE For launcher applications when the adhesive material is not facing the spacecraft (for example lower stagers of launcher, ground segment support applications), the requirements on cleanliness and contamination and outgassing specified in clause 5 of ECSS-Q-ST-70-02 can be tailored.

- f. An assessment of the bonding application shall be performed as basis for the adhesive selection.
- g. The assessment should include, but is not limited to:
 - 1. Joints design
 - (a) Mechanical loads
 - (b) Thermo-mechanical loads

- (c) Adherends
- (d) Geometrical Configuration
- (e) Shape of the bondline
- (f) Need of NDI
- 2. Adhesives properties
 - (a) Mechanical properties
 - (b) Thermo-mechanical properties
 - (c) Offgassing
 - (d) Moisture sensitivity
 - (e) Appearance
 - (f) Specific properties
- 3. Processing
 - (a) Surface preparation of adherends
 - (b) Curing conditions: time to full cure, temperature, pressure, humidity, time to handling strength
 - (c) Adhesive conditioning
 - (d) Viscosity
 - (e) Pot life
 - (f) Manual or machine processing
 - (g) Adhesive fillet removal (excess adhesive)
 - (h) Packaging and storage
- 4. Ground, launch, and in-orbit environment
 - (a) Radiation
 - (b) Vacuum
 - (c) Temperature range
 - (d) Thermal cycling
 - (e) Chemical compatibility
 - (f) Storage time and storage conditions
- 5. Procurement
 - (a) Cost factors
 - (b) Lead time
 - (c) Export control
 - (d) Obsolescence risk
- 6. Health and safety

NOTE 1 For requirement 5.2g.1(e): The shape of the bondline refers, for example, to the presence/absence of an outer fillet (excess glue)

NOTE 2 For requirement 5.2g.2(d): Sensitivity can be related to water absorption, water content in the adhesive, water desorption, CME, water diffusion.

NOTE 3 For requirement 5.2g.2(d): Accelerated hot-wet tests can be performed within screening activities in order to determine the moisture sensitivity of representative assembly.

NOTE 4 For requirement 5.2g.2(e): Optical applications can require either transparent or dark glues.

NOTE 5 For requirement 5.2g.2(f): Specific properties include electrical, thermal, optical, thermo-optical properties.

NOTE 6 For requirement 5.2g.3(g) variations in adhesive processing can modify final adhesive properties

NOTE 7 Further information about selection of adhesives can be found in section 7 of ECSS-E-HB-32-21.

h. Adhesives properties should be analysed based on:

1. Supplier information
2. Materials data bases
3. Data of tests relevant to the specific application

NOTE 1 Examples of Materials databases are: MAPTIS (NASA), MATREX (CNES), Granta MI, ESMDB (ESA), MIL handbooks.

NOTE 2 Examples of tests can be found in Annex D, Annex E and section 15 of ECSS-E-HB 32-21.

NOTE 3 Further information on adhesive characteristics and properties can be found in a section 6 of ECSS-E-HB-32-21.

NOTE 4 Tests applied for generation of missing data are based on national or international standards, list of tests can be found in Annex D, Annex E.

i. For application of adhesive tape for passive thermal control requirements from clause 4 of ECSS-Q-ST-70-09 shall apply for thermo-optical measurements.

NOTE Tape application procedure can have an impact on the tape thermo-optical properties.

Definition of adhesive bonding process

6.1 Adhesive bonding process requirements

- a. The adhesive bonding process shall be in compliance with the requirements specified as in clause 4.3.1 of ECSS-Q-ST-70-71.
- b. Process control of adhesive bonding shall be performed in compliance with the requirements from clause 7 of ECSS-Q-ST-70.
- c. The adhesive bonding process shall be performed according to the adhesive bonding procedure specified in DRD Annex A.
- d. Adherends and adhesive materials shall have the same temperature as the processing environment in order to avoid condensation during the bonding process.

NOTE 1 This means conditioning to the working temperature of materials taken from colder or warmer places than the bonding area.

NOTE 2 This can be described by an additional step: conditioning prior to bonding.

6.2 Adhesive bonding procedure

- a. An adhesive bonding procedure shall be issued by the supplier according to DRD Annex A.

NOTE 1 Preparation of the bonding procedure is considered as a multidisciplinary task.

NOTE 2 The bonding procedure can be a single document or split into several documents.

- b. The references relevant to adhesive bonding procedure shall be listed in the Declared Process List (DPL)
- c. The operators executing the bonding process shall proceed according to the adhesive bonding procedure.
- d. Training of the operators shall be done in accordance to the requirements in clause 8.11.

6.3 Adhesive bonding process traceability

- a. For process traceability the requirements from clause 5.2.5 of ECSS-Q-ST-20 shall apply.
- b. Date of the bonding process steps shall be recorded.

- c. Batch (production lot) number of primer and adhesive material used for bonding process shall be recorded.
- d. Operator identification shall be recorded.
- e. Records of requirements 6.3b, 6.3c and 6.3d shall be kept in the manufacturing file.

NOTE For requirement 6.3b the information about the execution time for bonding process steps can be useful.

Verification of adhesive bonding

7.1 Overview

The adhesive bonding of the flight hardware needs a careful analysis to determine its verification status with respect to the mission requirements. When verification is missing or not complete then a test plan is established.

The test plan is defined - to verify the performance of the flight hardware. Defined tests are therefore representative of flight conditions with, for example, representative loads being applied in representative directions.

7.2 Adhesive bonding test plan

- a. The supplier shall issue an adhesive bonding test plan according to the DRD in Annex B for customer approval for critical processes as defined in ECSS-Q-ST-70.

NOTE Customer approval is processed through a RFA.

- b. The adequacy and reliability of a bonding configuration and its associated process shall be demonstrated through a verification programme.

NOTE A bonding configuration is defined as a minimum by the adherends, the adhesive and the bonding process, see clause 7.7.

- c. Adhesive bonding performance properties to be tested shall be selected according to application needs.

NOTE 1 The bonding application assessment as described in clause 5.2 can be used to determine these parameters.

NOTE 2 The test item configuration is linked to the properties to be characterized.

- d. In the adhesive bonding test plan the supplier shall list all tests and inspections used during sub-sequential steps of verification test sequence in conformance with requirements from clause 7.7.
- e. The pass-fail criteria of the verification test sequence shall be specified by the supplier and submitted as part of the adhesive bonding test plan for customer approval.

7.3 Adhesive bonding test report

- a. The results of the test shall be documented in the adhesive bonding test report in conformance with the DRD from Annex C.

7.4 Test item bonding procedure

- a. The bonding procedure shall be in compliance with the DRD from Annex A.
- b. The bonding procedure used for test item shall be representative of flight hardware manufacturing.
- c. Any deviation between test items and flight hardware bonding procedure shall be justified and submitted for the customer approval.

NOTE Deviations can be related to differences in adhesive application, tooling manufacturing environment and to upscaling of in production.

7.5 Test item configuration

- a. Test items shall be representative of flight hardware configuration as a minimum for the following:
 1. Adhesive preparation and curing
 2. Adhesive application
 3. Primer preparation and curing
 4. Primer application
 5. Adherend materials
 6. Adhesive thickness
 7. Surface finishing of adherends
 8. Geometry
 9. Dimensions
 10. Surface preparation

NOTE 1 to item 7.5a.5: The precise chemical composition and material manufacturing process can be important for any type of material.

NOTE 2 to item 7.5a.7: Surface finishing is state of the surface before surface preparation prior adhesive bonding.

- b. Any deviation between test items and flight hardware configuration shall be justified and submitted for customer approval.

NOTE The justification rational can be included in the adhesive bonding test plan.

- c. Deviations in test item from flight hardware shall be justified for following:
 1. Adherends materials
 2. Adhesive preparation method
 3. Adhesive application
 4. Adhesive thickness
 5. Curing cycle
 6. Surfaces finishing of adherends

7. Geometry
 8. Dimensions
 9. Sandwich panel configuration
 10. Surface preparation
- d. In case a repair process of adhesive bond exists, the test items shall be manufactured and tested according to the verification sequence.

NOTE Typical examples of repairs are :
debonding/breakage of MLI studs, bonding of
additional fixtures in cabling.

7.6 Test item identification

- a. The supplier shall mark all test items with identification to maintain traceability in a way not to degrade the quality of the test item during testing.

NOTE This includes also untested spare test items.

- b. The supplier shall maintain the traceability of the following details of the test items submitted for testing:
1. Identification code of the test item
 2. Applicable documentation
 3. Details of the supplier of the assembly
 4. Type of product
 5. Adherend and adhesive materials
 6. Processing details, reference to the adhesive bonding procedure
 7. Batch numbers
 8. Test item quantity
 9. Test item manufacturing date
 10. Prepared by
 11. Any deviation to test item definition

7.7 Verification test sequence

7.7.1 General

- a. For the purpose of the verification test sequence the supplier shall identify the parameters affecting the performance of the adhesive bond within its life cycle.

NOTE Figure 4-2 shows some parameters from the on ground-life phase, pre-launch, launch and early orbit phase as well as the mission.

- b. The verification test sequence shall be in accordance with the flow chart from Figure 7-1.